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# Paper from soda-sulphur koroi pulp

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**Abstract:** Chips of suitable size of koroi were digested in an autoclave in laboratories by soda sulphur process with a view to obtaining optimum pulping conditions which were established by varying the amount of chemicals like caustic soda and sulphur, time, temperature, material–liquor ratio, etc. Emphasis was given on determining unbleached pulp-yield and permanganate number of pulp and physical properties of the brown pulp-sheets. Pulps obtained with the use of optimum pulping conditions were bleached by both CEH and CEHEH bleaching systems. Both unbleached and bleached pulps were disintegrated and beaten for 0-60 minutes and sheets were made from the different beaten samples and tested for breaking length, tear and burst factors. The brightness of the sheets and freeness of different pulps were also measured and recorded. Thus it appeared that soda-sulphur koroi pulp may be an effective source for making good quality writing and printing paper.
**Key words:** Soda sulphur, koroi, paper pulp

## Introduction

Koroi (*Albizzia procera* Roxb. Benth.) is included in leguminosae family. It is a large deciduous tree, 60-80 feet high, growing over 6 feet in circumference. It is a beautiful shaddy tree having wide branches full of leaves. The tree is commonly distributed from the Himalayas to Bangladesh. It grows on alluvial ground along stream and other moist soil. It is also planted throughout the country along road side. Koroi is mainly used for making furniture and also used as fuel in Bangladesh by the villagers. The chemical composition of koroi was determined by Technical Association of Pulp and Paper International (TAPPI) standards (TAPPI, 1-4, 1969). It contains alpha cellulose 40.00 (%), lignin 27.16 (%), pentosan 14.02 (%) and ash 01.01 (%). As no report was available for making pulp and paper from koroi by soda sulphur process, therefore the present studies were carried out in laboratories in details.

## Materials and Methods

A rotating closed autoclave (disestor) of 20 L capacity was used for pulp making from 500 g. o.d. chips of koroi in each experiment. Optimum pulping conditions were established on the basis of the unbleached (brown) pulp–yields and permanganate number (TAPPI-5,1969) of the pulp as well as determination of physical or paper properties of the pulp sheets (TAPPI-6,1969) by varying the amounts of chemicals like caustic soda and elemental sulphur, time, temperature and material–liquor ratio. Pulps, thus obtained with the use of optimum conditions, were bleached with 3 stage CEH and 5 stage CEHEH bleaching systems where C means chlorination, E means caustic extraction and H means hypochlorite treatment. The duration of chlorination, extraction and hypochlorite treatments were for 60 minutes in each case. The consistencies were respectively 3.5%, 13.5% and 3.5% for chlorination, extraction and hypochlorite treatment. The temperature for extraction was 70-80$^{o}$C and chlorination and hypochlorite treatment were carried out at room temperature. The pH of chlorination was 1-2 and that for hypochlorite solution was 9-11. Pulps were disintegrated and beaten in the Holander beater (TAPPI-7, 1969) for 0–60 minutes of time for determination of their paper properties like breaking length, tear factor, burst factor and brightness (TAPPI 8-11, 1969). The freeness in each case was also measured (TAPPI-12, 1969).

## Results and Discussion

The unbleached pulp yield of 44.54% obtained with soda sulphur pulping of koroi was higher than those obtained by others (Karim and Sarkar, 1988). Koroi contains 40% alpha cellulose. It indicates that there was practically no loss of alpha cellulose during pulping by soda-sulphur process. It is also evident that the highest pulp yield (44.54%) for koroi was obtained with the addition of 1.0% elemental sulphur to the cooking liquor consisting of NaOH solution only. Beyond 1.0% addition, the yields increased slightly but not to an appreciable amount due to which 44.54% was considered as the highest pulp-yield in the list of the table-1. Elemental sulphur reacts with NaOH of the cooking liquor and forms $Na_2S$ which hydrolyses to NaOH and NaSH (sodium hydrosulphite). As a result, the NaOH of the cooking liquor increases. There is also formation NaSH (in the liquor) which has a good beneficial effect in pulping. The presence of NaHS acts as a buffer and tends to reduce the degrading or injurious effect of the more active NaOH on cellulose and hemicellulose thus giving rise to higher pulp yield and stronger pulps. In addition, the NaSH reacts with lignin to produce thiolignin which helps lignin more readily soluble in alkali and thus reduced cooking time from 4 hours required by other workers in pulping koroi by soda and sulphate processes (Karim 1980, Karim and Sarker, 1988) to 2.5 hours in the present studies for soda-sulphur process and thus about 40% cooking time was saved.

The permanganate number for soda-sulphur koroi pulp was found to be 14.65 which is the lowest of all the koroi pulps obtained by the previous workers (Karim 1980, Karim and Sarker, 1988). The above permanganate number showed that the pulp-yields obtained with the respective optimum conditions of pulping were not at the expense of pulp purity indicating that the optimum cooking conditions were rightly selected and adequate for good delignification.

**Table 1 Variations in chemicals (NaOH and S), time, temperature and material liquor ratio along with permanganate number and unbleached yield of the pulp and brightness and physical or paper properties of the koroi pulp-sheets**

| Experiment | NaOH (%) | Sulphur (%) | Temperature $^0$C | Time including 50 minutes to reach temperature | Material-liquor ratio | Unbleached yield (%) | Permanganate number | Breaking length (m) | Tear factor | Burst factor | Brightness ( %) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.0 | 1.0 | 155 | 2.5 | 1 : 4 | 46.00 | 16.25 | 2419 | 53.09 | 49.35 | 29.6 |
| 2 | 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 2680 | 54.76 | 51.00 | 32.0 |
| 3 | 28.0 | 1.0 | 155 | 2.5 | 1 : 4 | 42.63 | 12.71 | 2807 | 50.50 | 53.79 | 35.3 |
| 4 | 26.0 | 0.0 | 155 | 2.5 | 1 : 4 | Not well digested | | | | | |
| 5 | 26.0 | 0.5 | 155 | 2.5 | 1 : 4 | 41.87 | 15.53 | 2641 | 54.01 | 50.49 | 31.5 |
| 6 | 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 2680 | 54.76 | 51.00 | 32.0 |
| 7 | 26.0 | 1.5 | 155 | 2.5 | 1 : 4 | 44.63 | 14.81 | 2705 | 54.16 | 51.44 | 32.4 |
| 8 | 26.0 | 2.0 | 155 | 2.5 | 1 : 4 | 44.70 | 15.03 | 2738 | 53.90 | 51.75 | 32.8 |
| 9 | 26.0 | 1.0 | 145 | 2.5 | 1 : 4 | Not well digested | | | | | |
| 10 | 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 2680 | 54.76 | 51.00 | 32.0 |
| 11 | 26.0 | 1.0 | 165 | 2.5 | 1 : 4 | 41.65 | 12.69 | 2939 | 49.94 | 57.82 | 35.4 |
| 12 | 26.0 | 1.0 | 155 | 1.5 | 1 : 4 | Not digested | | | | | |
| 13 | 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 2680 | 54.76 | 51.00 | 32.0 |
| 14 | 26.0 | 1.0 | 155 | 3.5 | 1 : 4 | 40.07 | 10.69 | 3200 | 45.51 | 58.55 | 40.5 |
| 15 | 26.0 | 1.0 | 155 | 2.5 | 1 : 3 | Not well digested | | | | | |
| 16 | 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 2680 | 54.76 | 51.00 | 32.0 |
| 17 | 26.0 | 1.0 | 155 | 2.5 | 1 : 5 | 44.32 | 14.40 | 2701 | 54.00 | 51.52 | 32.3 |

**Table 2 Optimum pulping conditions for soda-sulphur pulping of koroi along with permanganate number and unbleached pulp–yields of the pulp and brightness of the sheets**

| NaOH (%) | Sulphur (%) | Temperature $^o$C | Time in hours | Material-liquor ratio | Unbleached yield (%) | Permanganate number | Brightness (%) |
|---|---|---|---|---|---|---|---|
| 26.0 | 1.0 | 155 | 2.5 | 1 : 4 | 44.54 | 14.65 | 32 |

**Table 3 Bleached pulp-yield and brightness of the 3 stage bleached CEH and 5 stage bleached CEHEH soda-sulphur koroi pulp**

| Pulp | Bleached yield (%) | Brightness (%) |
|---|---|---|
| CEH | 41.50 | 80.1 |
| CEHEH | 40.17 | 81.7 |

**Table 4 Fibre-dimensions of soda sulphur koroi pulp**

| Pulp | Length in mm | | | Diameter in mm | | |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Average | Maximum | Minimum | Average |
| CEH | 1.52 | 0.68 | 1.09 | 0.030 | 0.015 | 0.021 |
| CEHEH | 1.50 | 0.68 | 1.06 | 0.029 | 0.014 | 0.021 |

200 fibres were taken for measurement.

**Table 5 Fibre-faction of soda sulphur koroi pulp**

| Pulp | Fibre faction in percent (%) | | | |
|---|---|---|---|---|
| | 0.50 – 0.99 mm | 1.00-1.49 mm | 1.50-1.99 mm | 2.00-2.49 mm |
| CEH | 40.00 | 60.00 | 0 | 0 |
| CEHEH | 51.46 | 48.54 | 0 | 0 |

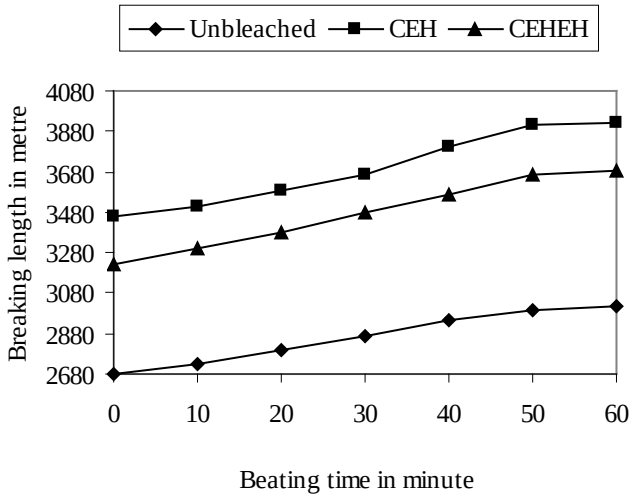


**Fig. 1.** The breaking length of the unbleached, CEH and CEHEH bleached soda sulphur koroi pulp

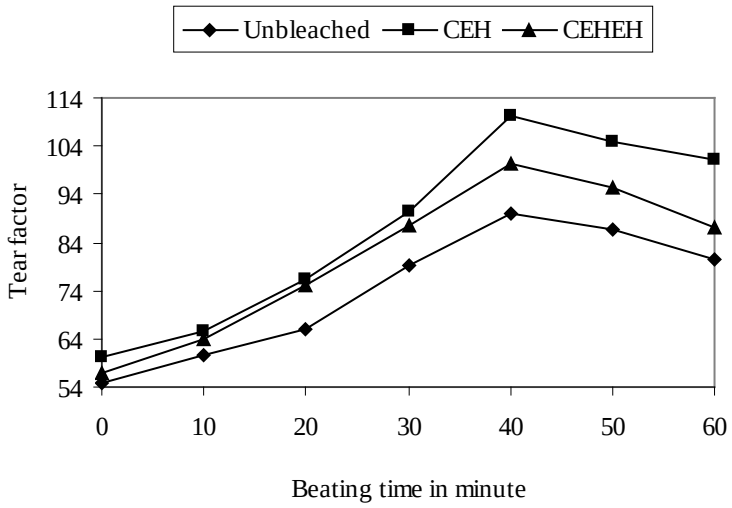


**Fig. 2.** The tear factor of the unbleached, CEH and CEHEH bleached soda sulphur koroi pulp

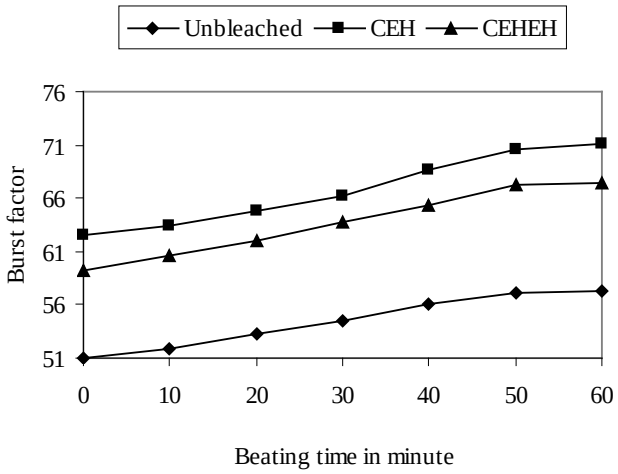


**Fig. 3.** The burst factor of the unbleached, CEH and CEHEH bleached soda sulphur koroi pulp

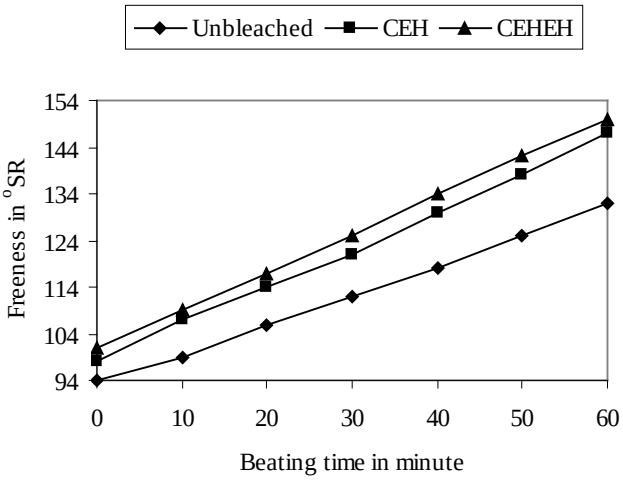


**Fig. 4**. The freeness of the unbleached, CEH and CEHEH bleached soda sulphur koroi pulp

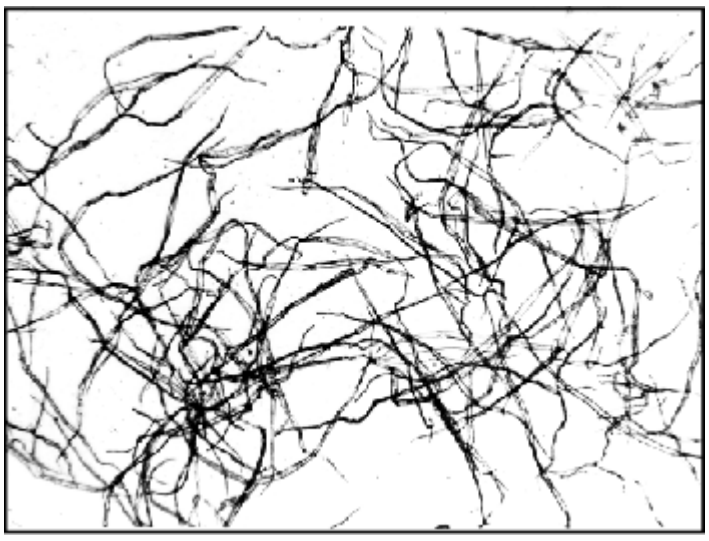

**Fig. 5.** The photomicrograph of the CEH soda-sulphur koroi pulp

The unbleached pulps were bleached with CEH and CEHEH bleaching systems. The chlorine water could not improve the brightness of the chlorinated pulp due to the formation of chlorolignin, though most of the residual lignin was removed. The two brightness values for CEH and CEHEH soda sulphur koroi pulps were respectively 80.1% and 81.7% very close to Karim's values such as 80 and 81 obtained for 5 stage soda and sulphate pulps (Karim 1980, Karim and Sarker, 1988). But the above two brightness values are much above the minimum values of 70 for paper making. From the photomicrograph it has been found that the fibres were thin-walled and contained parenchyma cells. The maximum fibre length of the CEH soda sulphur koroi pulp was 1.52 mm and the minimum length was 0.68 mm. 200 fibres were taken for measurement. The average fibre length was 1.09 mm. Its diameter varied from 0.015 mm to 0.030 mm and its average diameter was 0.021 mm. 60% of the fibres were in the range of 1.00 to 1.49 mm. The fibre length of the other CEHEH soda sulphur pulp was determined as 1.06 mm. From the two values and the corresponding values for soda and sulphate bleached pulps as obtained by the other worker (Karim, 1980) it indicated that there was minimum degradation for soda-sulphur pulp not only during pulping but also during subsequent stages of bleaching. From the fibre length studies it may be concluded that koroi is a short fibre pulp.

For laboratory evaluations of their properties, the unbleached, 3 stages CEH and 5 stages CEHEH bleached pulps were beaten for 0-60 minutes of time. The breaking length and burst factors of unbleached, 3 and 5 stage bleached pulps increased from 0 to 60 minutes, though the rate of increase decreased at the end of beating like others (Karim and Siddiquellah, 1975, Karim and Rahman, 1984, Karim and Islam 1985, Karim and Seal 2001). It is seen that the highest tear factor of soda-sulphur koroi pulp was 110.0 at its 40 minutes beating time with a freeness value of 130. The value is compared to that of 135 of jute-stick obtained with the 3 stage bleached soda-sulphur pulp at 50 minutes of beating time (Karim and Islam, 1989). The freeness of all koroi pulps of the present studies decreased during the time beating. From the overall studies it may be concluded by saying that the soda sulphur pulp of koroi is suitable for making writing and printing paper of high strength

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TAPPI-10, 1969. Determination of burst factor pulp sheets. T - 403 m – 53

TAPPI-11, 1969 Determination of brightness of pulp sheets. T - 402 m – 49

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